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The Accuracy of Magnetic Resonance Imaging in the Diagnosis of Meniscal and Cruciate Ligament Tears of the Knee

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Abstract

Background: During the past decade, magnetic resonance imaging (MRI) has been accepted as the ideal approach for primary diagnosis of traumatic knee intra-articular lesion. Despite this, the overall diagnostic accuracy of MRI has been carefully scrutinized in Iran. The purpose of this investigation was to scrutinize the diagnostic accuracy of MRI of the knee in identifying traumatic intra-articular knee lesions.

Methods: We compared MRI findings with subsequent arthroscopic findings (as the gold standard) in 107 patients (107 knees) with a clinical diagnosis of traumatic intra-articular knee lesion. The sensitivity, specificity, positive predictive value, negative predictive value, and the accuracy of MRI were calculated based on arthroscopic findings for menisci and cruciate ligaments.

Results: MRI showed the following results for medial meniscus: sensitivity 83%; specificity 37%; positive predictive value 46%; negative predictive value 77%; and accuracy 55%. For lateral meniscus it showed the following results: sensitivity 43%; specificity 86%; positive predictive value 40%; negative predictive value 87%; and accuracy 79%. MRI showed the following results for anterior cruciate ligament (ACL): sensitivity 62%; specificity 90%; positive predictive value 71%; negative predictive value 66%; and accuracy 75%. In addition, it showed the following results for posterior cruciate ligament (PCL): sensitivity 60%; specificity 94%; positive predictive value 42%; negative predictive value 98%; and accuracy 94%. The overall accuracy of MRI was 62.5%. We compared MRI accuracy in two time periods to investigate if there was any improvement over time. Our data showed a significant increase in the accuracy of detection of ACL injuries by MRI in more recent patients; however, there was no improvement in the diagnosis of other internal knee derangements. In addition, overall MRI accuracy was the same in patients from different age groups.

Conclusions: We concluded that the overall accuracy of MRI in diagnosing intra-articular lesions of the knee in Iran is comparable with other published studies in the literature. However, it could be improved; if radiologists and orthopedists work together to find possible flaws, their cooperation would result in optimal use of this diagnostic modality.

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Introduction

Intra-articular knee lesions can be associated with significant morbidity and may need to be treated surgically. Their correct diagnosis is of utmost importance, as delay in diagnosis can result in social and economic problems, and sometimes in a worse prognosis. Although there is a wide range of accuracy reported for clinical examination by MRI, and arthroscopy in the literature, magnetic resonance imaging (MRI) has been reported to have a high diagnostic sensitivity, specificity, and accuracy in the diagnosis of internal derangement of the knee in many studies (1-7). However, there was a general skepticism

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among orthopedic surgeons about the accuracy of MRI in Iran. This prospective study was designed to investigate the accuracy of MRI compared to arthroscopic findings (as a gold standard) in diagnosis of intra-articular lesions of the knee.

Materials and Methods

The present study was conducted at Imam University Hospital, which is one of the largest referral hospitals in Tehran, Iran. From April 2002 to April 2005, 107 patients, who met the inclusion criteria, were included in the study. There were 83 males and 18 females, and the average age of the study population was 27.9 years (range: 18-52). The inclusion criteria were restricted to patients with clinical diagnoses of either meniscal tears and/or cruciate ligaments rupture. Patients with other coexistent pathologies were excluded from this study group. Each patient underwent a detailed history and thorough physical examination at the time of initial evaluation. Patients were questioned regarding symptoms consistent with meniscal or cruciate ligament injuries, such as pain, swelling, episodes of giving way, and mechanical symptoms such as locking and catching. All clinical examination was performed by two senior authors of this essay (SMJM and MHK). Meniscal injuries were diagnosed by positive joint line tenderness, or McMurray or Apley tests. The integrity of ACL was examined by anterior drawer test, Lachman test, and the pivot-shift test. Posterior drawer test was used for investigation of PCL injury. Varus and valgus stress tests were also used. Standard radiographs were obtained for each patient. No patient sustained any additional injury to the knee between the time of clinical examination and the time of surgery.

MRI examinations were performed on all of the patients in the study. The MRI studies were performed at different centers throughout the country. We know the specifications of the MRI units; however, we could not have data on technical details that have been observed by technicians regarding the positioning of the knee and the machine setting. The written report of the radiologist was used as data for determining the accuracy of the MRI.

The senior authors of this study performed all of the arthroscopic procedures. For the purpose of this study, arthroscopy was considered as the gold standard mean to determine the cause of knee internal derangement.

Statistical analysis

MRI diagnoses were placed into one of four categories after arthroscopic evaluation. A result was regarded as true positive if the clinical or MRI diagnosis was confirmed by arthroscopic evaluation. A result was considered a true negative if diagnosis of no ruptures was confirmed by arthroscopy. A result was regarded as false positive if the arthroscopy was negative, but the results were positive at the clinical examination or on the MRI. If arthroscopy was positive, but the clinical examination and MRI were negative, it was regarded as false negative. To assess the reliability of the clinical and MRI results the five parameters of accuracy, sensitivity, specificity, positive predictive value, and negative predictive value were calculated. Statistical analysis was performed separately for medial meniscus tears, lateral meniscus tears, ACL tears, and PCL tears using SPSS for Windows (SPSS Inc., Chicago, IL, USA). We tried to perform cost analysis, but no MRI center approved to cooperate in this regard.

Results

There were 137 pathologies identified by arthroscopy in these 107 knees. There were 60 ACL tears, 5 PCL tears, 41 medial meniscus tears, and 18 lateral meniscus tears. The distribution of true positives, true negatives, false positives, and false negatives for MRI examination is shown in table 1. Table 2 demonstrates the sensitivity, specificity, positive and negative predictive values, and accuracy of MRI in diagnosing medial meniscus tears, lateral meniscus tears, ACL ruptures, and PCL ruptures.

Table 1. Number of true or false results for each pathology group

	Medial meniscus	Lateral meniscus	ACL	PCL
	MRI	MRI	MRI	MRI
True positives	35	18	37	3
True negatives	24	76	43	98
False positives	41	12	5	4
False negatives	7	2	5	2

ACL: anterior cruciate ligament; PCL: posterior cruciate ligament

Table 2. Results of the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of MRI for each type of pathology

	Medial meniscus	Lateral meniscus	ACL	PCL
Sensitivity	%83	42%	62%	60%
Specificity	%37	86%	90%	94%
PPV	%46	40%	71%	42%
NPV	%77	87%	66%	98%
Accuracy	55%	79%	75%	94%

ACL: anterior cruciate ligament; PCL: posterior cruciate ligament; PPV: positive predictive value; NPV: negative predictive value

We hypothesized that MRI accuracy May have improved as a result of the increase in the radiologists' experience. Therefore, we classified the patients into group A that included patients who underwent MRI exam before 20th December 2003, and group B that included those who received MRI after this time period. There were 63 and 44 patients in groups A and B, respectively. We compared the sensitivity,

Table 3. Results of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of MRI for each type of lesion in two groups of patients (group A, patients who underwent arthroscopic examination before December 20th 2003, and group B include patients who were operated on after December 20th 2003).

	Medial meniscus			Lateral meniscus			ACL			PCL		
	A	B	P-value	A	B	P-value	A	B	P-value	A	B	P-value
Sensitivity	53%	100%	< 0.001	46%	20%	0.005	48%	86%	0.001	75%	-	-
Specificity	54%	27%	0.008	87%	84%	0.66	88%	90%	0.75	98%	93%	0.19
PPV	73%	38%	0.10	53%	14%	0.001	85%	90%	0.44	75%	-	-
NPV	62%	100%	< 0.001	84%	89%	0.46	54%	87%	0.001	98%	97%	0.75
Accuracy	53%	50%	0.22	77%	77%	1	65%	88%	0.006	96%	90%	0.21

ACL: anterior cruciate ligament; PCL: posterior cruciate ligament; PPV: positive predictive value; NPV: negative predictive value

specificity, positive and negative predictive values, and accuracy of MRI examination in these two groups (table 3). The accuracy of MRI did not differ significantly between the two groups for all lesions; except ACL, for which diagnostic accuracy has significantly increased in group B.

We also studied the influence of patients' age on MRI accuracy in diagnosing intra-articular lesions. Therefore, we classified the patients into four groups: group 1: 0-15 years of age; group 2: 15-30 years of age; group 3: 30-45 years of age, and group 4: over 45 years of age (8). Statistical analysis showed that the overall accuracy of the MRI was the same in all groups (Table 4). Table 5 shows the overall accuracy of MRI in the diagnosis of any intra-articular lesion.

Table 4. The agreement of MRI findings with arthroscopic findings in different age groups

		Age groups				Total	P-value
		1	2	3	4		
MRI agreement	Yes	0	19	14	2	35	
with arthroscopy	No	0	46	21	5	72	0.533
Total		0	65	35	7	107	

Table 5. The overall sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of MRI in detecting intra-articular lesions for this study

Sensitivity	**85.3%**
Specificity	79.5%
PPV	60%
NPV	67%
Accuracy	65.2%

PPV: positive predictive value; NPV: negative predictive value

Discussion

Since its introduction for clinical use in the mid-1980s, the role of magnetic resonance imaging (MRI) in the diagnosis of knee lesions has been established. MRI has proven reliable and safe, and offers advantages over diagnostic arthroscopy, which is currently regarded as the reference standard for the diagnosis of internal derangements of the knee. Arthroscopy is an invasive procedure with certain risks and discomfort for the patient. Moreover, it is preferably performed only for treatment purposes, provided that alternative noninvasive diagnostic modalities such as MRI are available and this modality is accurate (9,10).

Results of numerous diagnostic studies have been published in which MRI and arthroscopy of the knee were compared, and most have shown good diagnostic performance in detecting lesions of the menisci and cruciate ligaments (4,9,11-21) The overall accuracy of MRI for meniscal and cruciate ligament injuries in our study was 65.2%, which is significantly different from the previous mentioned studies, which had accuracy rates of 79 to 89%.[22] We compared the sensitivity and specificity of MRI for each component in our study with the results of a meta-analysis of 29 studies by Oei et al. (23).

The MRI identified meniscal tears with a sensitivity of 85.4% was in agreement with previously published papers (50-100%: mean, 84.7%) and the meta-analysis of Oei (2-4,10,18,21,23,24). The specificity of 61.3% is significantly lower than figures reported earlier with an average specificity of 86.1% reported in previous articles.[23] This means that, In our study, MRI examination could not correctly exclude people without meniscal lesions. The positive predictive value of 65.3% was also similar to other studies (others, 42% to 95%, mean = 77.3%), which also indicates that the probability of finding meniscal tear in a patient with positive MRI report is high. The negative predictive value of 91.7% was similar to reports by others (others, 83% to 100%, mean, 83.3%) which means it is highly probable to find normal meniscus in arthroscopic examination of patients with normal MRI report. This is an important point that indicates that in patients with normal MRI we can avoid unnecessary arthroscopy, provided that its difference with clinical examination is significant. MRI has been shown to accurately diagnose tears of the meniscus approximately 85% of the time (range = 48% to 94%) in other studies, while our results showed 71.1% accuracy which is also significantly lower (1,2,10,18,21,25-27).

We had 53 (49%) false positive meniscal tear readings on MRI, which is significantly higher than other studies. This is either an over-reading of the MRI, or the lesion is missed in arthroscopy. Some reports in the radiology literature have suggested that, without any clinical data to support their contention, arthroscopy misses posterior horn tears of medial

meniscus (1,3,28,29). The main argument is whether we should classify this as a false positive MRI result or a false negative result for arthroscopy. Several authors reported that most false positive results with MRI were observed in posterior horn of the medial and to a lesser degree lateral meniscus (3,21,24) All of our false positive results were in posterior part of the menisci (41 medial meniscus, 12 lateral meniscus). Degenerative meniscal tears have been noted to increase with aging, but in children and preadolescents the normal meniscal vasculature may cause increased signal intensity. However, in our study the MRI accuracy did not differ in different age groups.

In Munk et al. study, in assessment of ACL lesions the MRI has a specificity of 90% and an accuracy of 75%, which was less than the later studies, but it seemed to be acceptable in comparison to some other studies with a specificity 96% and an accuracy of 82% (3) The 62% sensitivity was also comparable to some studies; however, it needs to be improved as this diagnostic modality is performed prior to arthroscopy and some patients with ACL injuries could go undiagnosed. On the other hand, we could not rely on normal MRI alone to rule out ACL injuries. Our study showed that the sensitivity of MRI in diagnosing ACL significantly increased in patients who were investigated after December 2003. We showed a similar significant increase in sensitivity of MRI for medial meniscus tears.

Negative predictive value of MRI is of great importance, because it could help us avoid unnecessary arthroscopy. We think that if the negative predictive value of MRI was higher than the negative predictive value of clinical examination, it would be helpful in decision making for patients with suspected internal derangement of the knee. We did not compare the results of clinical examination and MRI examination of the knee, as the main purpose of this study was to evaluate MRI accuracy in finding intra-articular knee lesions.

There is indeed a large variation in accuracy from center to center, varying from 64% to 94%.[18] Differences in accuracy could also result from differences in scanning protocol. Multiple radiologists were included in this study. Using a single radiologist would have improved the consistency of radiographic diagnoses (1). MRI accuracy may improve as radiologists gain more experience and use more effective protocol. There are several reports indicating that the level of diagnostic accuracy in meniscal and cruciate ligament tears of the knee is comparable for low- and high-field-strength MR imagers (17,11)

MRI will be able to ultimately achieve a clear-cut advantage over clinical examination through technological improvement and as clinical experience is gained. However, at this time, we need to know its flaws and try to improve its accuracy. We think that radiologists and orthopaedic surgeons should work closely together not only to give radiologists the access to the history and clinical examination of the patients, but also the results of arthroscopic finding. This may be the only way they can continuously audit the results of MRI examination of the knee and improve the accuracy of this useful diagnostic modality.

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